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(54) **FILTERING APPARATUS, FILTERING METHOD, AND WATER TREATMENT SYSTEM**

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(57) **ABSTRACT**

A filtering apparatus includes a cylindrical filter including a cylindrical screen filter, a treated water nozzle including a nozzle port, a casing where the cylindrical filter is accommodated, the casing containing the nozzle port in the inside, a filtered water flow channel through which filtered water obtained by passage of water to be treated through the screen filter is guided to the outside of the casing, the filtered water flow channel being provided with a flow inlet provided in the inside of the casing, and a rotation mechanism that rotates the cylindrical filter with a central axis of the cylindrical filter. A distance between a centerline of the nozzle port along a direction of outflow of water to be treated and the central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

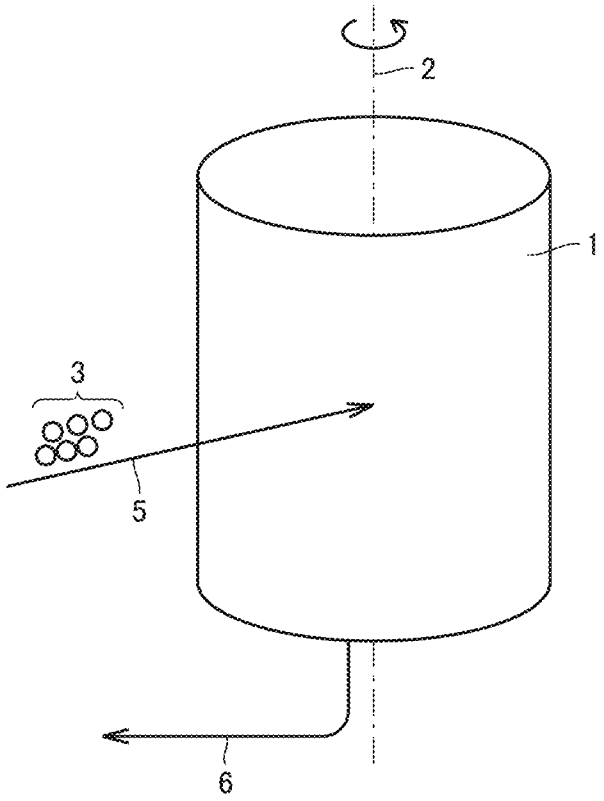


FIG.1

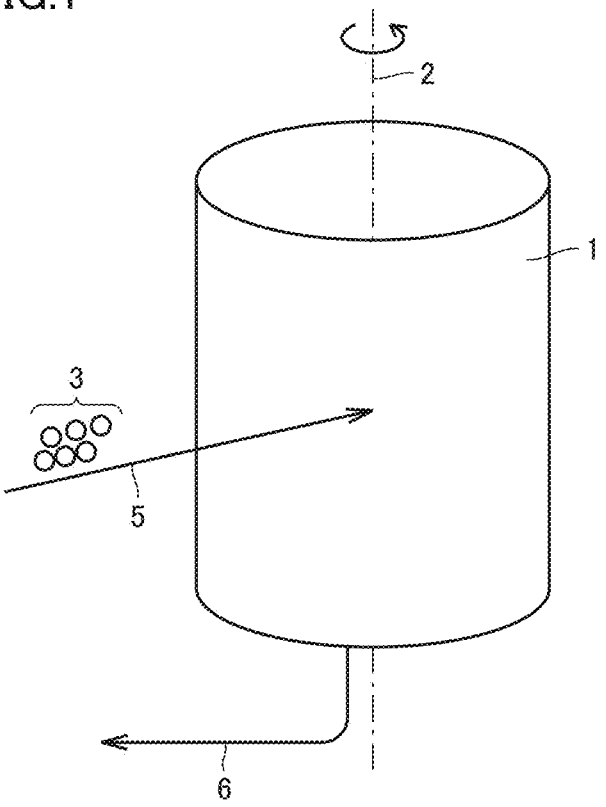


FIG.2

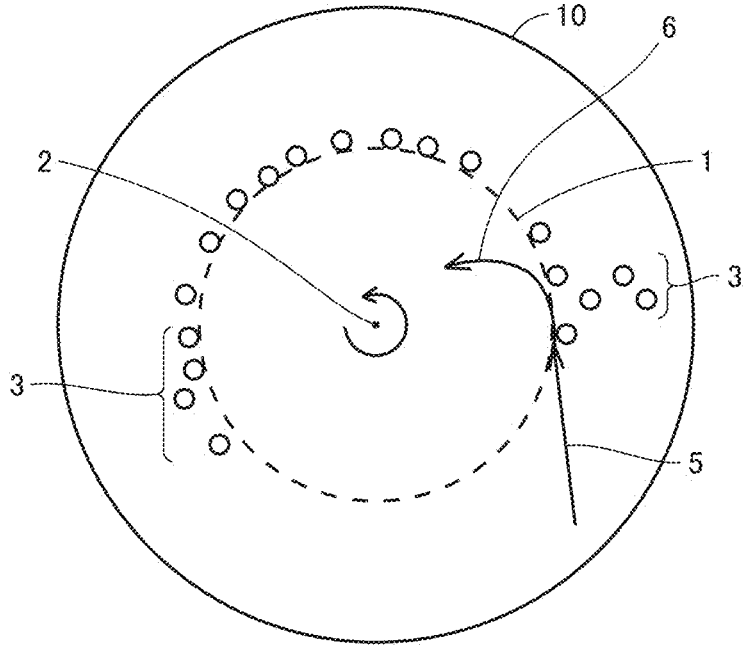


FIG.3

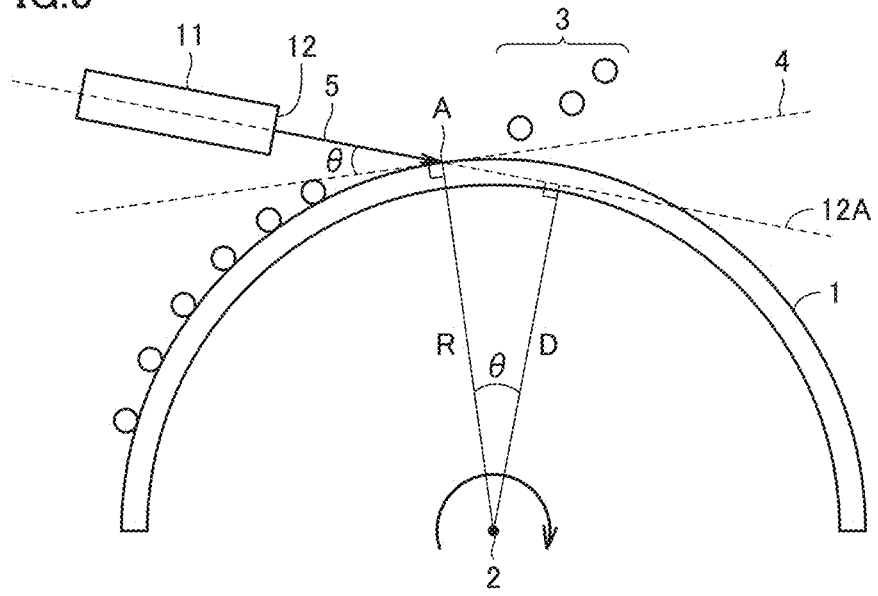


FIG.4

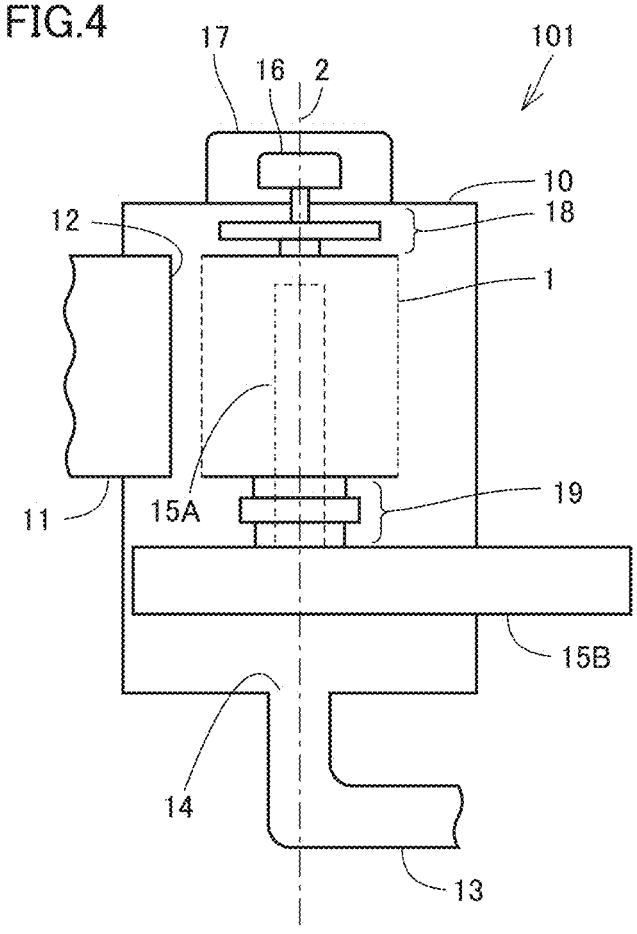
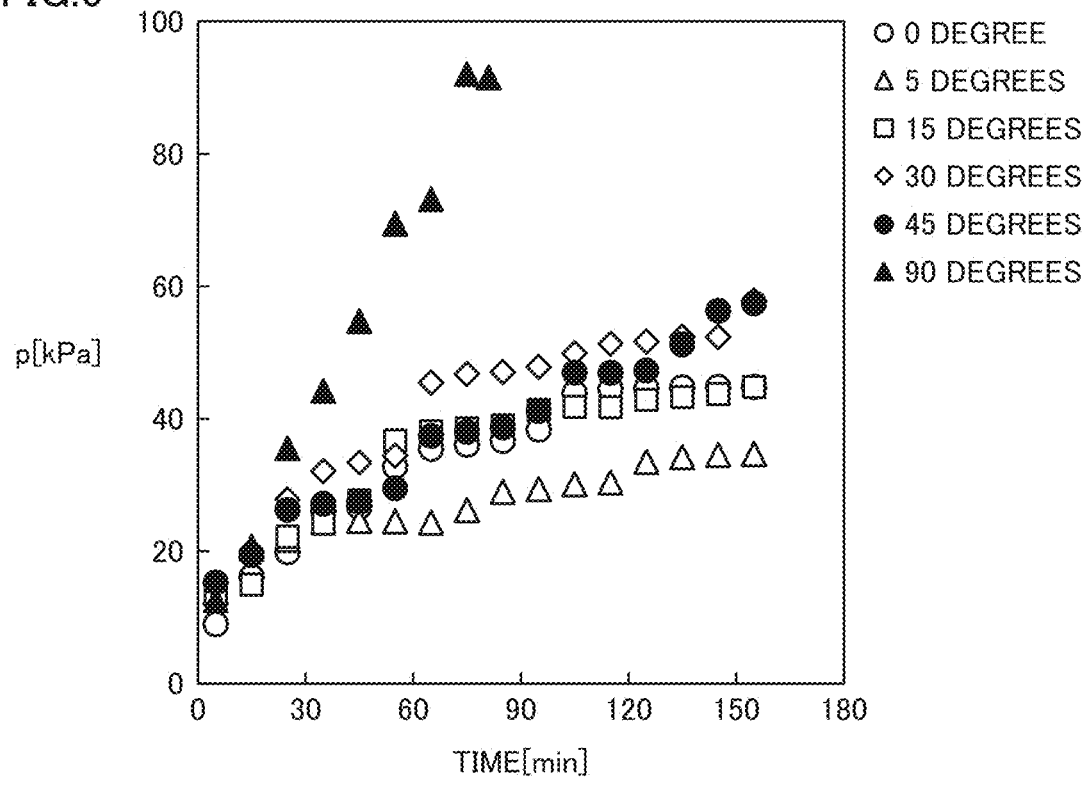


FIG.5


100
80
60
40
20
0
p[kPa]
0
30
60
90
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30 DEGREES
45 DEGREES
90 DEGREES

FIG.6

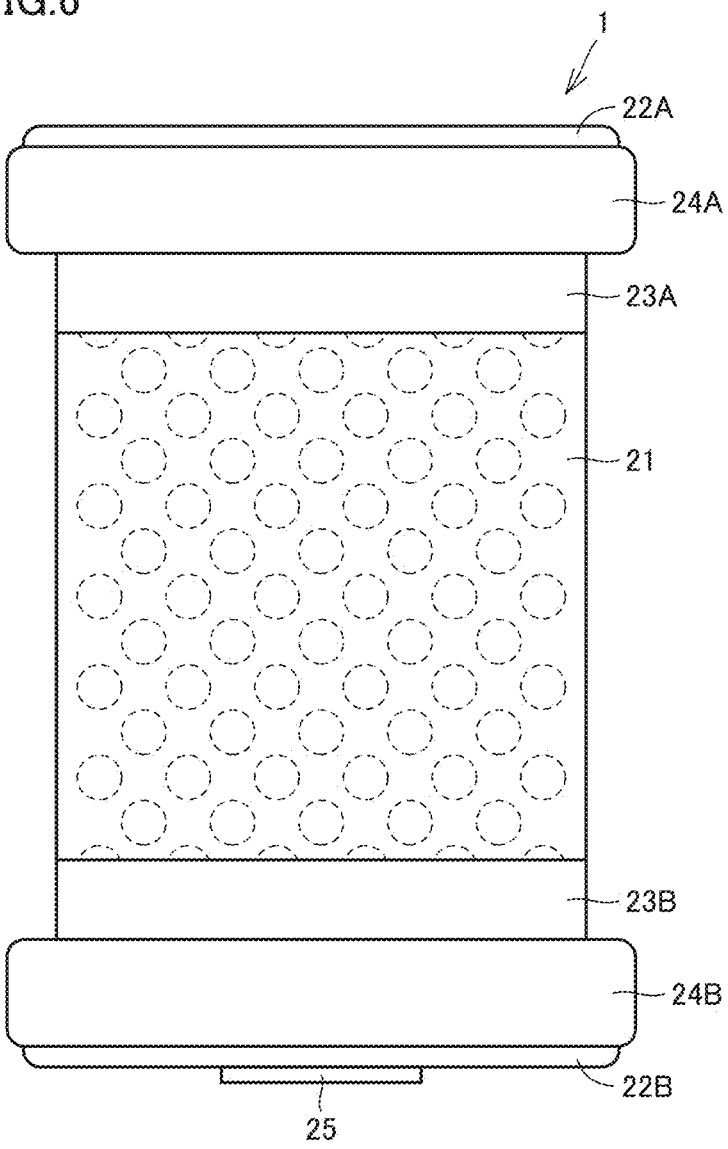


FIG.7

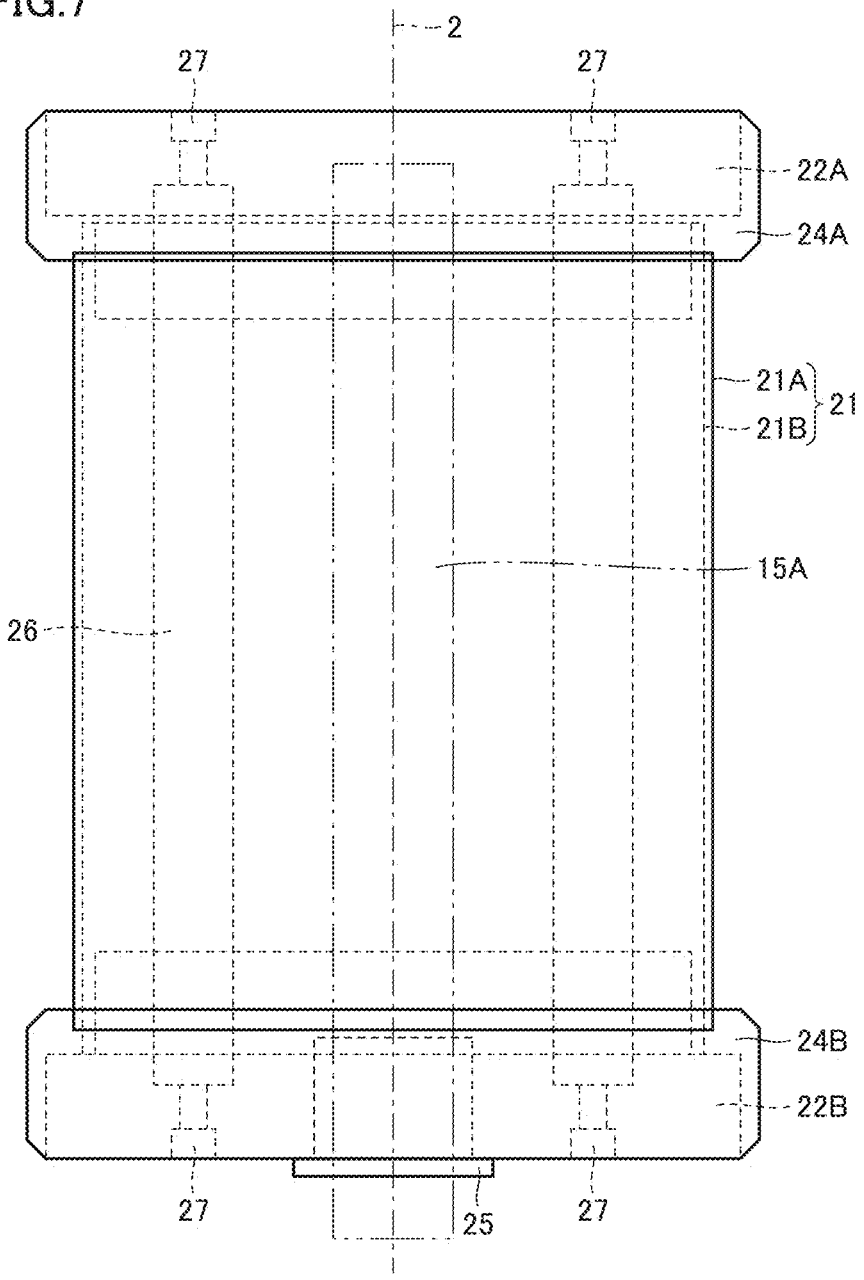


FIG.8

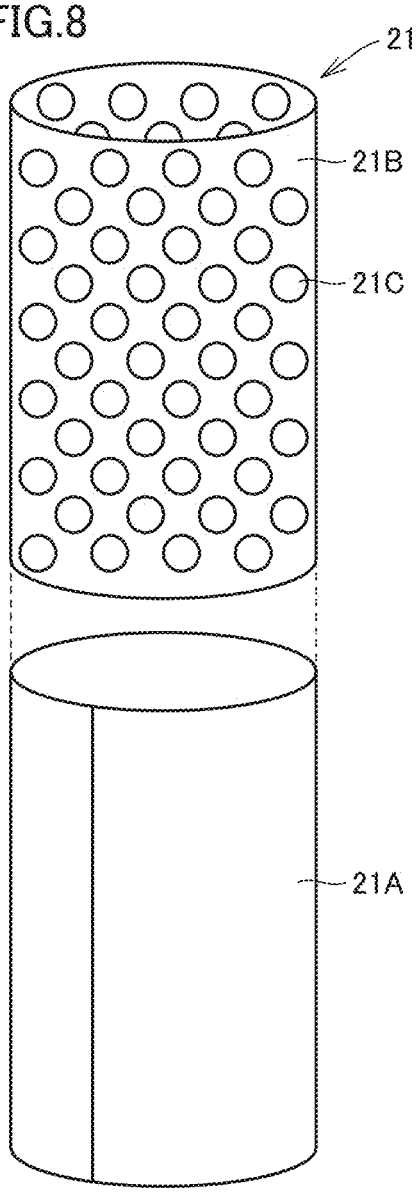


FIG.9

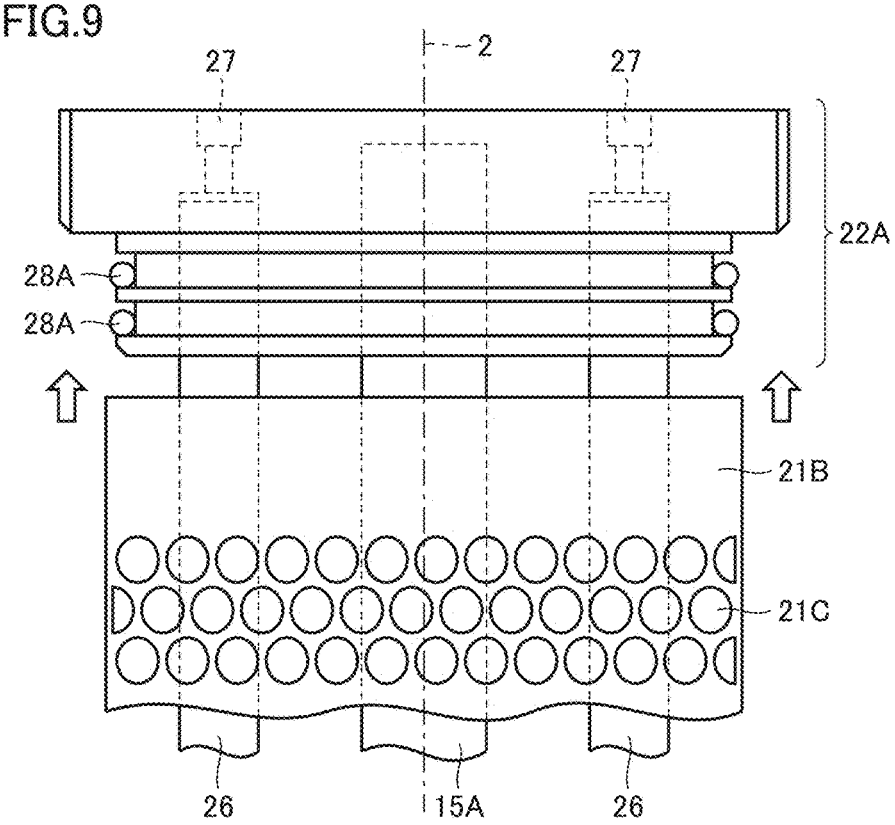
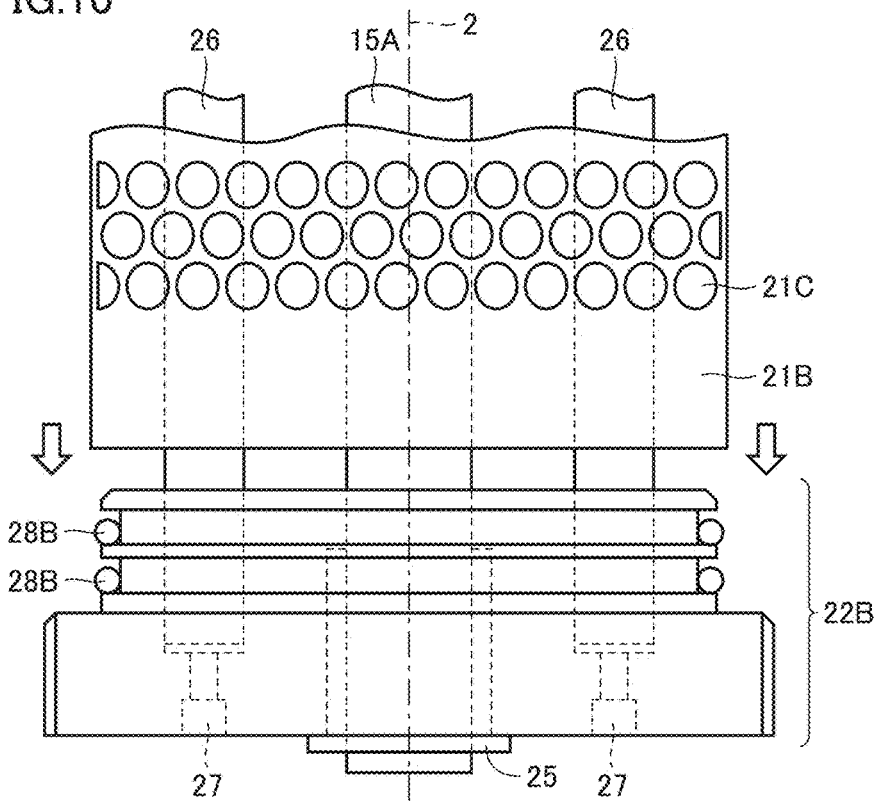

27
2
27
22A
28A
28A
21B
21C
26
15A
26

FIG.10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15A
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21C
21B
28B
28B
22B
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25
27

FIG.11

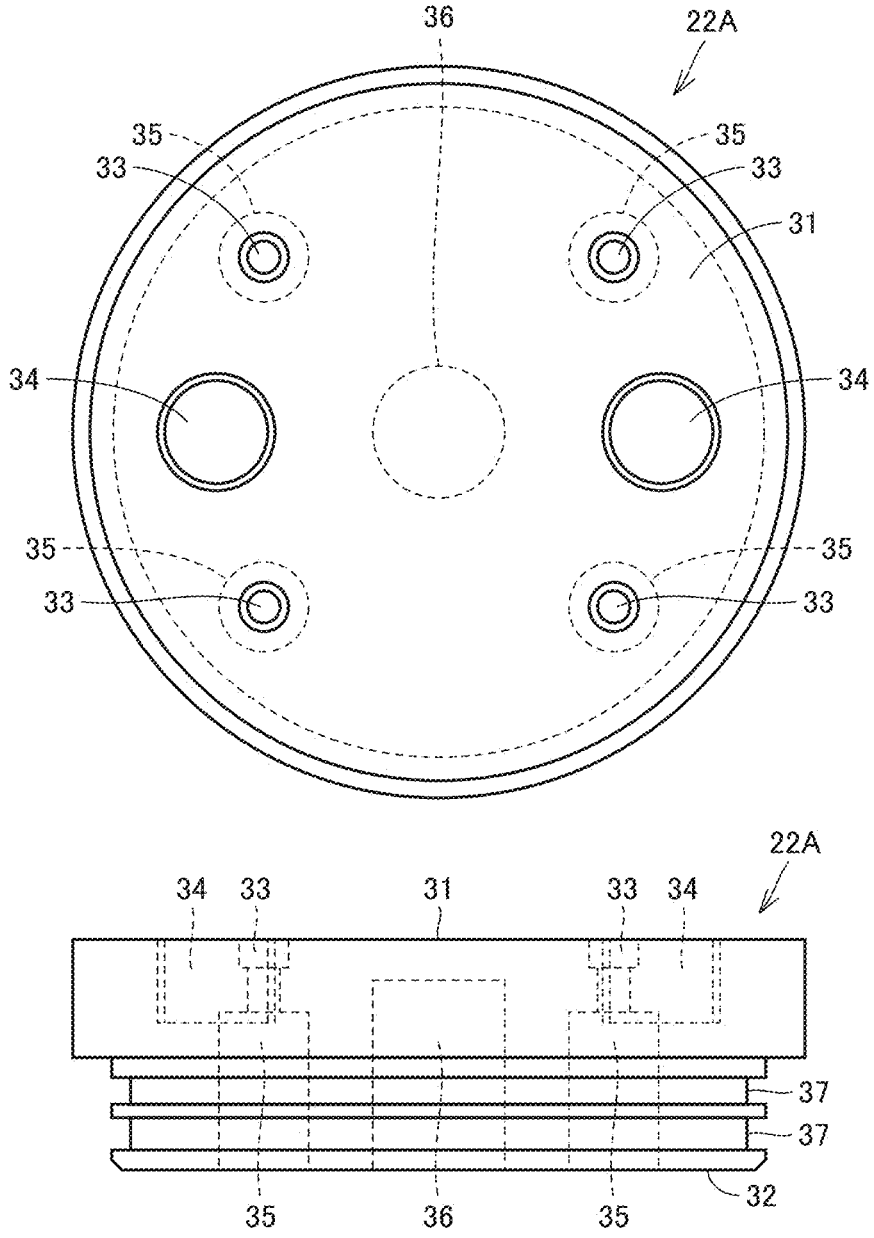
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FIG.12

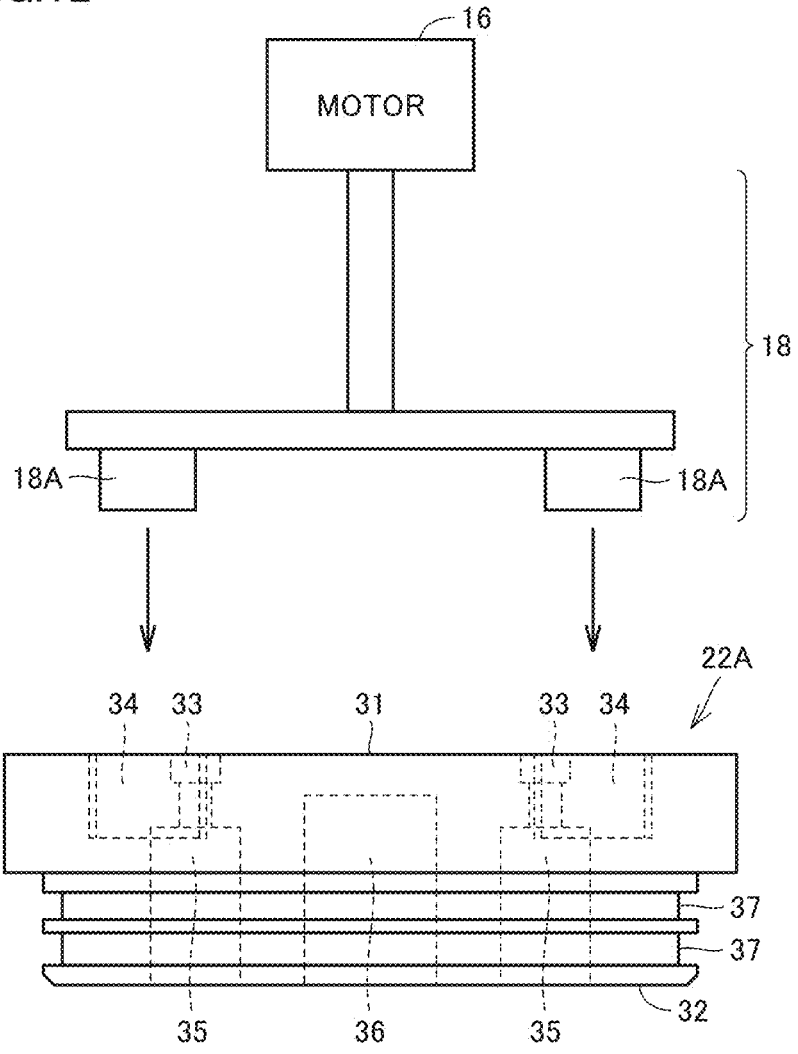


FIG.13

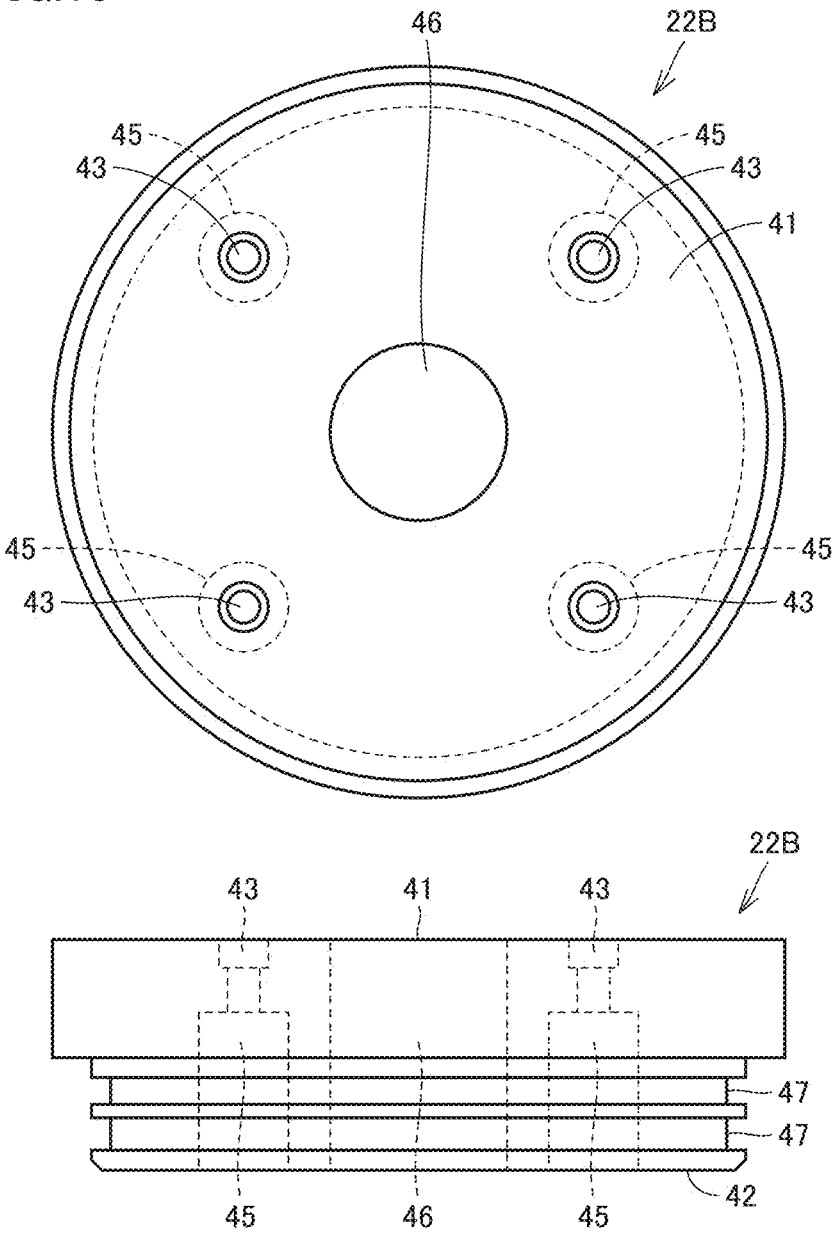


FIG.14

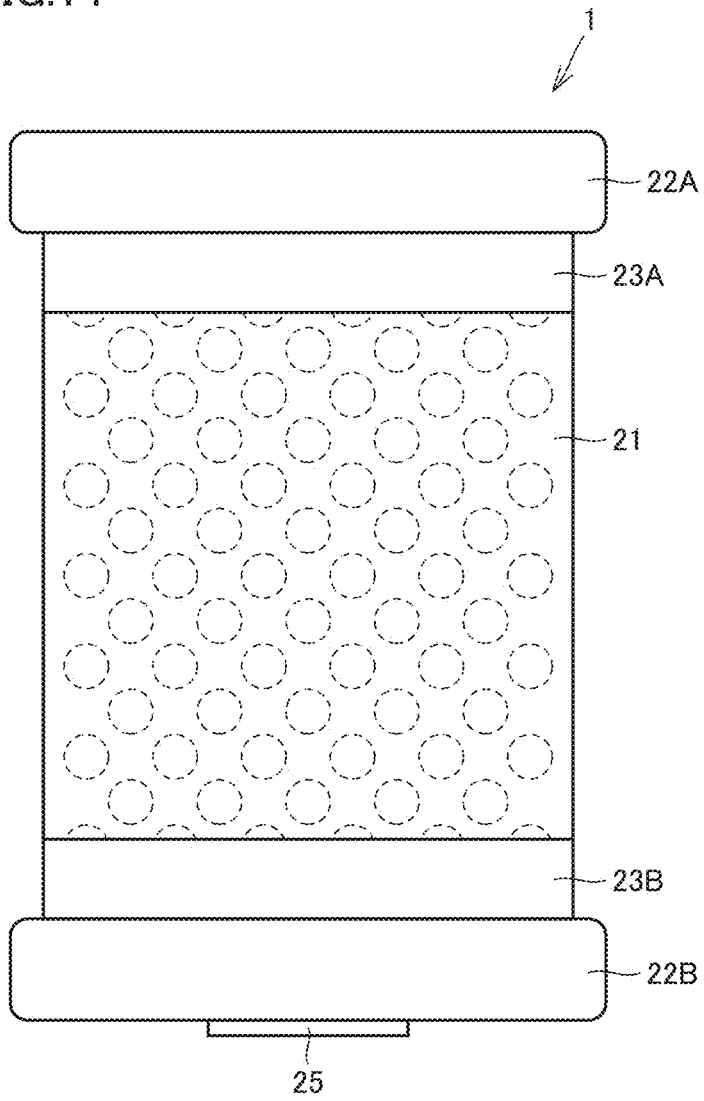
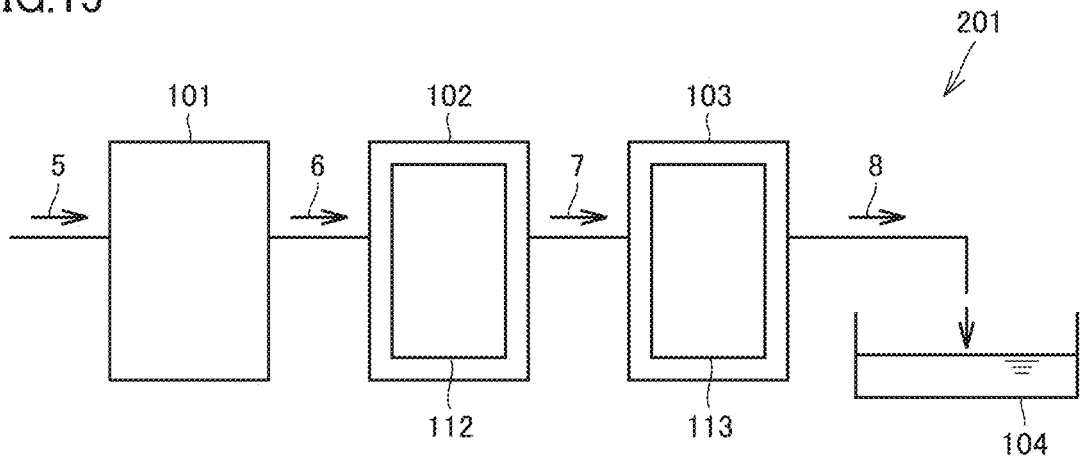


FIG.15



FILTERING APPARATUS, FILTERING METHOD, AND WATER TREATMENT SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to a filtering apparatus, a filtering method, and a water treatment system. The present application claims priority to Japanese Patent Application No. 2022-043274 filed with the Japan Patent Office on Mar. 18, 2022, the entire contents of which are hereby incorporated by reference.

BACKGROUND ART

[0002] For example, Japanese Patent Laying-Open No. 2015-9170 (PTL 1) discloses a cylindrical filter and a ballast water treatment apparatus including the same. For example, a porous structure such as a nonwoven fabric is employed as a material for the cylindrical filter.

CITATION LIST

Patent Literature

[0003] PTL 1: Japanese Patent Laying-Open No. 2015-9170

SUMMARY OF INVENTION

[0004] A filtering apparatus according to one aspect of the present disclosure includes a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric, a treated water nozzle including a nozzle port through which water to be treated flows out to a surface of the screen filter, a casing where the cylindrical filter is accommodated, the casing containing the nozzle port in the inside, a filtered water flow channel through which filtered water obtained by passage of water to be treated through the screen filter is guided to the outside of the casing, the filtered water flow channel being provided with a flow inlet provided in the inside of the casing, and a rotation mechanism that rotates the cylindrical filter with a central axis of the cylindrical filter being defined as a center. A distance between a centerline of the nozzle port along a direction of outflow of water to be treated and the central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

[0005] A water treatment system according to one aspect of the present disclosure is a water treatment system including the filtering apparatus described above.

[0006] A filtering method according to one aspect of the present disclosure is a filtering method of filtering water to be treated by a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric. The filtering method includes rotating the cylindrical filter and causing water to be treated to flow out of a nozzle port of a treated water nozzle such that water to be treated passes through the screen filter. The causing water to be treated to flow out includes causing water to be treated to flow out in such a direction that a distance between a centerline of the nozzle port along a direction of outflow of water to be treated and a central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. **1** is a schematic diagram schematically showing a filtering method according to an embodiment of the present disclosure.

[0008] FIG. **2** is a diagram for illustrating a mechanism of filtering of water to be treated with the filtering method according to the embodiment of the present disclosure.

[0009] FIG. **3** is a schematic diagram for illustrating cleaning of a filter by filtering treatment according to the embodiment of the present disclosure.

[0010] FIG. **4** is a schematic cross-sectional view showing overview of a construction of a filtering apparatus according to the embodiment of the present disclosure.

[0011] FIG. **5** is a diagram illustrating an effect obtained by the filtering method according to one embodiment of the present disclosure.

[0012] FIG. **6** is a diagram showing the entire cylindrical filter (filter cartridge) according to one embodiment of the present disclosure.

[0013] FIG. **7** is a diagram showing a construction of the cylindrical filter shown in FIG. **6**.

[0014] FIG. **8** is an exploded view of a filter main body.

[0015] FIG. **9** is a partial assembly diagram showing assembly of an upper portion of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure.

[0016] FIG. **10** is a partial assembly diagram showing assembly of a lower portion of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure.

[0017] FIG. **11** is a top view and a side view of an upper lid body of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure.

[0018] FIG. **12** is a schematic diagram showing coupling between a rotation mechanism and the upper lid body of the cylindrical filter (filter cartridge).

[0019] FIG. **13** is a bottom view and a side view of a lower lid body of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure.

[0020] FIG. **14** is a diagram showing another form of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure.

[0021] FIG. **15** is a block diagram schematically showing an exemplary water treatment system including the filtering apparatus according to the embodiment of the present disclosure.

DETAILED DESCRIPTION

Problem to be Solved by the Present Disclosure

[0022] Depending on water quality, a filter made of a nonwoven fabric is clogged in a short period of time by objects floating in water. Factors for clogging include surface deposition and internal obstruction. Surface deposition refers to such a phenomenon that particles larger than an average pore diameter of a filter are deposited on a surface of the filter and a layer of a lump called a cake is formed. Internal obstruction refers to such a phenomenon that particles smaller than an average pore diameter of a filter remain in the inside of the filter to clog a flow channel.

[0023] A cake layer can be removed by cleaning of the surface of the filter with a water flow. There are, however, small projections and recesses in the surface of the filter.

Therefore, in cleaning of the surface of the filter, a solid may remain in those small recesses. Therefore, an effect of cleaning of the surface of the filter with a water flow should further be enhanced in order to maintain filtering performance of a filtering apparatus.

[0024] An object of the present disclosure is to provide a filtering apparatus capable of continuing filtering treatment while clogging of a filter is suppressed, a filtering method with the use of the filtering apparatus, and a water treatment system including the filtering apparatus.

ADVANTAGEOUS EFFECT OF THE PRESENT DISCLOSURE

[0025] According to the present disclosure, a filtering apparatus capable of continuing filtering treatment while clogging of a filter is suppressed, a filtering method with the use of the filtering apparatus, and a water treatment system including the filtering apparatus can be provided.

DESCRIPTION OF EMBODIMENT OF THE PRESENT DISCLOSURE

[0026] Manners in which the present disclosure is carried out will initially be listed and described.

[0027] (1) A filtering apparatus according to one aspect of the present disclosure includes a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric, a treated water nozzle including a nozzle port through which water to be treated flows out to a surface of the screen filter, a casing where the cylindrical filter is accommodated, the casing containing the nozzle port in the inside, a filtered water flow channel through which filtered water obtained by passage of water to be treated through the screen filter is guided to the outside of the casing, the filtered water flow channel being provided with a flow inlet provided in the inside of the casing, and a rotation mechanism that rotates the cylindrical filter with a central axis of the cylindrical filter being defined as a center. A distance between a centerline of the nozzle port along a direction of outflow of water to be treated and the central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

[0028] According to the above, the filtering apparatus capable of continuing filtering treatment while clogging of the filter is suppressed can be realized. The cylindrical filter is formed from a screen filter made of a woven fabric or a nonwoven fabric having a thickness, for example, not larger than 200 μm. Since the screen filter has a small thickness, internal obstruction is less likely. Therefore, a main factor for clogging of the screen filter is surface deposition. The nozzle port is directed to the surface of the screen filter such that the distance between the centerline of the nozzle port along the direction of outflow of water to be treated and the central axis of the cylindrical filter is smaller than the radius of the cylindrical filter. A solid (cake layer) deposited on the screen filter can be removed by a water pressure of water to be treated that flows out of the nozzle port. Furthermore, small recesses located in the vicinity of the surface of the screen filter can also be cleaned by a jet of water to be treated. Therefore, filtering treatment can continue while clogging of the filter is suppressed. The "woven fabric" refers to a fabric, for example, formed by weaving resin fibers or metallic wires, and a material therefor is not particularly limited.

[0029] (2) In the filtration apparatus in (1), an angle formed by the centerline of the nozzle port with respect to a tangent of the cylindrical filter at an intersection between the centerline of the nozzle port and a surface of the cylindrical filter is equal to or larger than 1° and equal to or smaller than 45°.

[0030] According to the above, water to be treated is incident obliquely to the tangent of the cylindrical filter. Since the pressure of water to be treated applied to the surface of the screen filter can be increased, not only the solid deposited on the screen filter can be removed but also small recesses located in the vicinity of the surface of the screen filter can be cleaned.

[0031] (3) In the filtration apparatus in (2), the angle is equal to or larger than 5° and equal to or smaller than 15°.

[0032] According to the above, an effect of cleaning of the surface of the screen filter with water to be treated can be enhanced.

[0033] (4) In the filtration apparatus in any one of (1) to (3), the cylindrical filter includes a cylindrical filter support including a surface in contact with an inner circumferential surface of the screen filter, the filter support having a plurality of holes provided in the surface, a strut arranged in the inside of the filter support, the strut extending along a direction of the central axis of the cylindrical filter, a first fixing member arranged at a first end of the filter support to fix the strut at the first end, a second fixing member arranged at a second end of the filter support opposite to the first end to fix the strut at the second end, a first sealing member that seals a gap between the first fixing member and the screen filter on a side of the first end of the filter support, and a second sealing member that seals a gap between the second fixing member and the screen filter on a side of the second end of the filter support. The rotation mechanism includes a coupling portion including a protruding portion. The first fixing member is provided with a recess constructed to receive the protruding portion of the coupling portion. The second fixing member is provided with a through hole for passage of the filtered water flow channel.

[0034] According to the above, the screen filter is supported by the filter support. The filter support is fixed by the strut, the first fixing member, and the second fixing member. Furthermore, the gap between the screen filter and the filter support can be sealed with the first sealing member and the second sealing member. The screen filter is thus cylindrically supported. In addition, since the recess in the first fixing member is provided to receive the protruding portion of the coupling portion of the rotation mechanism, the first fixing member and the rotation mechanism can be coupled to each other. Water to be treated can thus be filtered by the screen filter while the cylindrical filter is rotated. Since filtered treated water passes through the holes provided in the filter support, treated water can be taken out of the filtered water flow channel.

[0035] (5) A water treatment system according to one aspect of the present disclosure includes the filtering apparatus described in any one of (1) to (4).

[0036] According to the above, the filtering apparatus useful for the water treatment system that requires filtering of water to be treated as pre-treatment can be realized. Applications of the water treatment system are not particularly limited.

[0037] (6) A filtering method according to one aspect of the present disclosure is a filtering method of filtering water to be treated by a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric. The filtering method includes rotating the cylindrical filter and causing water to be treated to flow out of a nozzle port of a treated water nozzle such that water to be treated passes through the screen filter. The causing water to be treated to flow out includes causing water to be treated to flow out in such a direction that a distance between a centerline of the nozzle port along a direction of outflow of water to be treated and a central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

[0038] According to the above, the filtering apparatus capable of continuing filtering treatment while clogging of the filter is suppressed can be realized.

DETAILS OF EMBODIMENT OF THE PRESENT DISCLOSURE

[0039] An embodiment of the present disclosure will be described in detail below with reference to the drawings. The same or corresponding elements in the drawings have the same reference characters allotted and description thereof will not be repeated.

[0040] FIG. **1** is a schematic diagram schematically showing a filtering method according to an embodiment of the present disclosure. FIG. **2** is a diagram for illustrating a mechanism of filtering of water to be treated with the filtering method according to the embodiment of the present disclosure.

[0041] As shown in FIGS. **1** and **2**, in the filtering method according to the embodiment of the present disclosure, a cylindrical filter **1** is used to filter water to be treated **5** to produce filtered water. As shown in FIG. **2**, cylindrical filter **1** is accommodated in a casing **10**.

[0042] Cylindrical filter **1** is a filter obtained by forming a screen filter in a cylindrical shape. In this embodiment, a woven fabric or a nonwoven fabric having a thickness, for example, not larger than 200 μm is employed as the screen filter. A type of yarns to be used for the woven fabric is not particularly limited, and metallic (for example, SUS) wires or resin fibers may be applicable.

[0043] The nonwoven fabric is a sheet obtained by intertwining fibers, rather than weaving fibers. The nonwoven fabric is defined, for example, under JIS L0222. A type of resin fibers to be used for the nonwoven fabric is not particularly limited.

[0044] As water to be treated **5** passes through cylindrical filter **1**, a separation target **3** is removed from water to be treated **5** and filtered water is obtained. Separation target **3**, on the other hand, adheres to a surface of cylindrical filter **1**. In the embodiment of the present disclosure, while cylindrical filter **1** rotates around a central axis **2** of the cylinder, water to be treated **5** flows toward the surface of cylindrical filter **1** (cylinder). In addition to rotation of cylindrical filter **1**, a flow of water to be treated **5** toward the surface of cylindrical filter **1** (cylinder) can remove separation target **3** from the surface of cylindrical filter **1**. Therefore, formation of the cake layer at the surface of cylindrical filter **1** can be prevented. As shown in FIGS. **1** and **2**, an orientation of rotation of cylindrical filter **1** is the same as an orientation of the flow of water to be treated **5**.

[0045] FIG. **3** is a schematic diagram for illustrating cleaning of the filter by filtering treatment according to the embodiment of the present disclosure. As shown in FIG. **3**, water to be treated **5** gushes out from a treated water nozzle **11**. Treated water nozzle **11** is provided with a nozzle port **12** (opening) directed to cylindrical filter **1** (screen filter).

[0046] In FIG. **3**, a centerline **12**A represents a centerline of nozzle port **12** along a direction of outflow of water to be treated **5**. Centerline **12**A intersects with the surface of cylindrical filter **1** (screen filter) at a point A. A tangent **4** is a virtual plane in contact with the surface of cylindrical filter **1** (screen filter) at point A.

[0047] A radius of curvature of cylindrical filter **1** (screen filter) is denoted as R. Radius of curvature R is equal to a distance from central axis **2** of cylindrical filter **1** to tangent **4**. In other words, R represents a length of a normal from central axis **2** of the cylinder to tangent **4**. This normal intersects with tangent **4** at point A. Furthermore, a distance between centerline **12**A of nozzle port **12** and central axis **2** of cylindrical filter **1** is denoted as D.

[0048] In the embodiment of the present disclosure, distance D is shorter than radius of curvature R of cylindrical filter **1**. In other words, relation of $D<R$ is satisfied. As nozzle port **12** is directed toward the surface of cylindrical filter **1** so as to satisfy relation of $D<R$, a water pressure of water to be treated **5** that flows out of nozzle port **12** can remove a solid (cake layer) deposited on the screen filter. Furthermore, small recesses located in the vicinity of the surface of the screen filter can also be cleaned with a jet of water to be treated **5**. Therefore, filtering treatment can continue while clogging of the filter is suppressed.

[0049] A condition of $D<R$ described above can also be explained with reference to an angle θ between centerline **12**A of nozzle port **12** and tangent **4**. Angle θ is equal to an angle between the normal from central axis **2** of cylindrical filter **1** to tangent **4** (a line segment that connects central axis **2** and point A to each other) and a line segment that connects central axis **2** of cylindrical filter **1** and centerline **12**A of nozzle port **12** to each other.

[0050] In the embodiment of the present disclosure, angle θ is larger than 0°. Preferably, angle θ is equal to or larger than 1° and equal to or smaller than 45°. With angle θ being equal to or larger than 1°, in addition to the effect of removal of a solid (cake layer) by a jet of water to be treated **5**, the effect of cleaning of small recesses located in the vicinity of the surface of the screen filter can also be obtained. With a larger angle θ, on the other hand, a jet of water to be treated **5** may interfere with rotation of cylindrical filter **1**. With angle θ being equal to or smaller than 45°, while interference with rotation of cylindrical filter **1** by a jet of water to be treated **5** is avoided, water to be treated **5** can be filtered and the surface of the screen filter can be cleaned. The effect of cleaning of the surface of the screen filter when angle θ is varied will be described in detail later.

[0051] FIG. **4** is a schematic cross-sectional view showing overview of a construction of a filtering apparatus according to the embodiment of the present disclosure. As shown in FIG. **4**, a filtering apparatus **101** according to the embodiment of the present disclosure includes cylindrical filter **1**, casing **10**, treated water nozzle **11**, a drain flow channel **13**,

filtered water flow channels **15**A and **15**B, a motor **16**, a motor cover **17**, a coupling portion **18**, and a bearing portion **19**.

[0052] Casing **10** contains therein, nozzle port **12** of treated water nozzle **11**, a drain outlet **14** of drain flow channel **13**, and filtered water flow channels **15**A and **15**B, and cylindrical filter **1** and motor **16** are accommodated in casing **10**. Casing **10** may be formed as being integrated with treated water nozzle **11**, drain flow channel **13**, and filtered water flow channels **15**A and **15**B.

[0053] Cylindrical filter **1** is a filter in a cylindrical shape which includes a woven fabric or a nonwoven fabric having a thickness, for example, not larger than 200 μm as the screen filter. Treated water nozzle **11** includes nozzle port **12** through which water to be treated flows out to the surface of the cylindrical filter. A height of nozzle port **12** is not particularly limited. In one embodiment, the height of nozzle port **12** may be lower than a height of cylindrical filter **1**.

[0054] Filtered water flow channels **15**A and **15**B are flow channels for guiding treated water (filtered water) filtered by cylindrical filter **1** from the inside of casing **10** to the outside of casing **10**. Filtered water flow channel **15**A passes through the inside of cylindrical filter **1**. Therefore, a through hole for passage of filtered water flow channel **15**A is provided at a lower end of cylindrical filter **1**. Filtered water flow channels **15**A and **15**B communicate with each other. Filtered water that passes through cylindrical filter **1** is taken into a flow inlet of filtered water flow channel **15**A and flows through filtered water flow channel **15**A, and is taken out of filtered water flow channel **15**B.

[0055] Drain flow channel **13** is a flow channel for draining drain water containing a separation target removed by cylindrical filter **1** to the outside of casing **10**. Though not shown, a valve may be provided in drain flow channel **13**. An amount of treatment by the filtering apparatus can be controlled by control of opening and closing of the valve.

[0056] For example, while cylindrical filter **1** filters water to be treated, the valve may be closed. Filtering apparatus **101** can filter water to be treated while it cleans cylindrical filter **1**. Since a total amount of water to be treated **5** supplied to filtering apparatus **101** can thus be filtered through filtering apparatus **101**, filtered water production capability can be enhanced. After filtering of water to be treated by cylindrical filter **1** ends, the valve is opened. A separation target accumulated in the inside of casing **10** during filtering treatment can thus be ejected through drain flow channel **13** to the outside of filtering apparatus **101**. During filtering of water to be treated, the valve may be open. In this case, water to be treated can be filtered while some of water to be treated that flows in is drained.

[0057] Motor **16** rotates cylindrical filter **1** around central axis **2** of the cylinder. In order to obtain desired torque for rotation of cylindrical filter **1**, a reduction gear may be combined with motor **16**. Motor cover **17** is attached to casing **10** to cover motor **16** (and the reduction gear).

[0058] A rotation shaft of motor **16** (a rotation shaft of the reduction gear in an example where motor **16** is coupled to the reduction gear) is coupled to coupling portion **18**. At an upper end of cylindrical filter **1**, cylindrical filter **1** is coupled to motor **16** (or the reduction gear) with coupling portion **18** being interposed. Thus, as motor **16** rotates, cylindrical filter **1** rotates. Motor **16** (or combination of motor **16** and the reduction gear) and coupling portion **18** correspond to the rotation mechanism for rotation of cylindrical filter **1**. On a lower end side of cylindrical filter **1**, on the other hand, bearing portion **19** for support of rotating cylindrical filter **1** is provided.

[0059] FIG. **5** is a diagram illustrating an effect obtained by the filtering method according to one embodiment of the present disclosure. In a graph shown in FIG. **5**, the abscissa represents a duration of filtering treatment with the filtering method according to the embodiment of the present disclosure and the ordinate represents a pressure loss p (unit: kPa) of the cylindrical filter.

[0060] The graph in FIG. **5** shows a degree of increase in pressure loss with the duration of filtering treatment when experiments were conducted with the angle (see FIG. **3**) between the centerline of nozzle port **12** and the tangent of the filter being varied. A flow rate in supply of water to be treated to the filter was the same regardless of the angle.

[0061] As the effect of cleaning of the surface of the filter is greater, progress of clogging of the filter is suppressed and hence the degree of increase in pressure loss is lower. Based on comparison of the degree of increase in pressure loss during the duration of filtering treatment from zero minute to ninety minutes, pressure loss when the angle between the centerline of nozzle port **12** and the tangent is between zero degree and forty-five degrees is smaller than pressure loss when the angle is ninety degrees, and can be suppressed to substantially ½ or lower.

[0062] Furthermore, when the angle between the centerline of nozzle port **12** and the tangent of the filter is five degrees, the degree of increase in pressure loss is lower than when the angle is zero degree, fifteen degrees, thirty degrees, and forty-five degrees. This may be because the recesses in the surface of the filter were more effectively cleaned. It was confirmed that, with the longer duration of filtering, the degree of increase in pressure loss when the angle was fifteen degrees was lower than the degree of increase in pressure loss when the angle was thirty degrees and forty-five degrees. This may be because, as the angle is larger, the cake layer at the surface of the filter was removed by water to be treated, however, the effect of cleaning of the recesses in the surface of the filter became weaker. Therefore, the angle between the centerline of nozzle port **12** and the tangent is preferably between more than zero degree (for example, one degree) and forty-five degrees and further preferably between five degrees and fifteen degrees.

[0063] In the embodiment of the present disclosure, cylindrical filter **1** can be a cartridge type filter. A replaceable filter can thus be realized.

[0064] FIG. **6** is a diagram showing the entire cylindrical filter (filter cartridge) according to one embodiment of the present disclosure. FIG. **7** is a diagram showing a construction of the cylindrical filter shown in FIG. **6**. As shown in FIGS. **6** and **7**, cylindrical filter **1** includes a filter main body **21**, lid bodies **22**A and **22**B, sealing tapes **23**A and **23**B, sealing members **24**A and **24**B, a bearing ring **25**, a strut **26**, and a screw **27**. For the sake of convenience of illustration, FIG. **6** does not show strut **26** and screw **27** and FIG. **7** does not show sealing tapes **23**A and **23**B.

[0065] Filter main body **21** includes a screen filter **21**A and a cylindrical filter support **21**B.

[0066] Strut **26** is arranged in the inside of filter support **21**B to extend along a direction of central axis **2** of cylindrical filter **1**.

[0067] Lid body **22**A is arranged at a first end (upper end) of filter support **21**B to close an opening at the first end. Lid

body **22**B is arranged at a second end (lower end) of filter support **21**B opposite to the first end to close an opening at that end. Strut **26** located on an upper end side of filter support **21**B has an end fixed to lid body **22**A by screw **27**. Similarly, strut **26** located on a lower end side of filter support **21**B also has an end fixed to lid body **22**B by screw **27**. Strut **26** is thus fixed to lid bodies **22**A and **22**B and filter support **21**B is supported by strut **26** and lid bodies **22**A and **22**B.

[0068] Sealing tapes **23**A and **23**B are wound around the upper end and the lower end of cylindrical screen filter **21**A, respectively. Sealing tapes **23**A and **23**B fix screen filter **21**A to filter support **21**B and bury a gap between screen filter **21**A and filter support **21**B.

[0069] Sealing member **24**A is provided at the upper end of filter support **21**B so as to surround sealing tape **23**A and lid body **22**A. Sealing member **24**B is provided at the lower end of filter support **21**B so as to surround sealing tape **23**B and lid body **22**B. Sealing members **24**A and **24**B seal the gap between screen filter **21**A and filter support **21**B, together with sealing tapes **23**A and **23**B. Therefore, in this embodiment, sealing member **24**A and sealing tape **23**A correspond to the first sealing member that seals the gap between lid body **22**A and screen filter **21**A on the upper end side of filter support **21**B. Similarly, sealing member **24**B and sealing tape **23**B correspond to the second sealing member that seals the gap between lid body **22**B and screen filter **21**A on the lower end side of filter support **21**B.

[0070] A through hole is provided in lid body **22**B for passage of filtered water flow channel **15**A in the inside of filter support **21**B. Bearing ring **25** is inserted in the through hole in lid body **22**B. Lid body **22**A covers the upper end of filtered water flow channel **15**A.

[0071] FIG. **8** is an exploded view of filter main body **21**. As shown in FIG. **8**, filter support **21**B is cylindrical. Filter support **21**B is provided with a surface where a plurality of holes **21**C are provided. By way of example, filter support **21**B is formed by working a perforated metallic sheet (which is generally called "punching metal") into a cylindrical shape.

[0072] Screen filter **21**A is wound such that the surface of filter support **21**B is in contact with an inner circumferential surface of screen filter **21**A. Therefore, the cylindrical screen filter is formed.

[0073] FIG. **9** is a partial assembly diagram showing assembly of an upper portion of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure. FIG. **9** does not show sealing tape **23**A and sealing member **24**A shown in FIG. **6**. As shown in FIG. **9**, the upper end of strut **26** is inserted in lid body **22**A and fixed to lid body **22**A by screw **27**. Furthermore, filtered water flow channel **15**A passes through filter support **21**B and filter **22**A covers a state of filtered water flow channel **15**A. In this state, lid body **22**A is attached to the upper end of filter support **21**B. In order to bury the gap between lid body **22**A and filter support **21**B, an O ring **28**A is attached to lid body **22**A.

[0074] FIG. **10** is a partial assembly diagram showing assembly of a lower portion of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure. FIG. **10** does not show sealing tape **23**B and sealing member **24**B shown in FIG. **6**. As shown in FIG. **10**, the lower end of strut **26** is inserted in lid body **22**B and fixed to lid body **22**B by screw **27**. Furthermore, bearing ring **25** is inserted in the through hole in lid body **22**B. Filtered water flow channel **15**A passes through a hollow portion in bearing ring **25** in this state, and lid body **22**B is attached to the lower end of filter support **21**B. In order to bury the gap between lid body **22**B and filter support **21**B, an O ring **28**B is attached to lid body **22**B.

[0075] FIG. **11** is a top view and a side view of the upper lid body of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure. As shown in FIG. **11**, lid body **22**A is provided with a top surface **31** and a lower surface **32**. In top surface **31** of lid body **22**A, a plurality of screw holes **33** for passage of screws for fixation of the strut and recesses **34** are provided. In lower surface **32** opposite to top surface **31**, a plurality of holes **35** for reception of struts and a hole **36** that receives filtered water flow channel **15**A (see FIG. **4**) are provided. By fastening screw **27** to strut **26**, strut **26** is fixed to lid body **22**A (see FIG. **9**). Recess **34**, however, does not reach lower surface **32** of lid body **22**A. Similarly, hole **36** provided in lower surface **32** does not reach top surface **31**.

[0076] Hole **36** is provided in a central portion of lower surface **32** of lid body **22**A. Two recesses **34** are arranged in symmetry with respect to hole **36**. Similarly, four holes **35** and four screw holes **33** are arranged in symmetry with respect to hole **36**.

[0077] Lid body **22**A is inserted in the opening at the end (upper end) of filter support **21**B to close the end (upper end) of that filter support **21**B. A groove **37** is provided in a portion of lid body **22**A inserted in the end (upper end) of filter support **21**B. In order to enhance hermeticity at the upper end of filter support **21**B, O ring **28**A may be fitted in groove **37** (see FIG. **9**).

[0078] FIG. **12** is a schematic diagram showing coupling between the rotation mechanism and the upper lid body of the cylindrical filter (filter cartridge). As shown in FIG. **12**, coupling portion **18** is provided with a protrusion **18**A. Recess **34** in lid body **22**A is provided in the top surface of lid body **22**A to receive protrusion **18**A. Lid body **22**A and coupling portion **18** are thus coupled to each other.

[0079] FIG. **13** is a bottom view and a side view of the lower lid body of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure. As shown in FIG. **13**, lid body **22**B is provided with a top surface **41** and a lower surface **42**. In top surface **41** of lid body **22**B, a plurality of screw holes **43** for passage of screws **27** for fixation of struts **26** are provided. In lower surface **42** opposite to top surface **41**, a plurality of holes **45** for reception of struts **26** are provided. The plurality of screw holes **43** communicate with respective holes **45** corresponding to screw holes **43**. As screw **27** is fastened to strut **26**, strut **26** is fixed to lid body **22**B (see FIG. **10**).

[0080] Lid body **22**B is inserted in the opening at the end (lower end) of filter support **21**B to close the end (lower end) of that filter support **21**B. A groove **47** is provided in a portion of lid body **22**B inserted in the end (lower end) of filter support **21**B. In order to enhance hermeticity at the upper end of filter support **21**B, O ring **28**B may be fitted in groove **47** (see FIG. **10**).

[0081] A through hole **46** extending from top surface **41** to lower surface **42** is provided in the central portion of lid body **22**B. Through hole **46** is a hole for passage of filtered water flow channel **15**A (see FIG. **4**). Bearing ring **25** is

inserted in through hole **46**. Four holes **45** and four screw holes **43** are arranged in symmetry with respect to through hole **46**.

[0082] FIG. **14** is a diagram showing another form of the cylindrical filter (filter cartridge) according to the embodiment of the present disclosure. As is understood based on comparison with the construction shown in FIG. **6**, in a construction shown in FIG. **14**, sealing members **24**A and **24**B have been omitted from cylindrical filter (filter cartridge) **1**. The gap between screen filter **21**A and filter support **21**B (see FIG. **7**) in filter main body **21** may be sealed only with sealing tapes **23**A and **23**B.

[0083] As described above, according to the embodiment of the present disclosure, the filtering apparatus useful for a water treatment system that requires filtering of water to be treated as pre-treatment can be realized. By way of example, the filtering apparatus according to the embodiment of the present disclosure can be applied to a water treatment system. Though a type of the water treatment system including the filtering apparatus according to the embodiment of the present disclosure is not particularly limited, one specific example will be described below.

[0084] FIG. **15** is a block diagram schematically showing an exemplary water treatment system including the filtering apparatus according to the embodiment of the present disclosure. Referring to FIG. **15**, the water treatment system according to the embodiment of the present disclosure can be realized, for example, as a saline water conversion system **201**. Saline water conversion system **201** includes filtering apparatus **101** described above, a filtering apparatus **102** including a filter **112** formed from an ultrafiltration membrane (UF membrane) or a microfiltration membrane (MF membrane), and a reverse osmosis membrane permeation apparatus **103** including a filter **113** formed from a reverse osmosis membrane (RO membrane). A pore diameter of filter **112** is smaller than a pore diameter of cylindrical filter **1** of filtering apparatus **101**.

[0085] In saline water conversion system **201**, filtering apparatus **101** according to the embodiment of the present disclosure is used as a pre-filter and filters water to be treated **5** which is sea water. Filtered water **6** is further filtered by filtering apparatus **102**. Filtered water **7** from filtering apparatus **102** is supplied to reverse osmosis membrane permeation apparatus **103**. As filtered water **7** passes through filter **113** of reverse osmosis membrane permeation apparatus **103**, pure water **8** is produced. Pure water **8** is stored in a tank **104**.

[0086] It should be understood that the embodiment disclosed herein is illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims rather than the embodiment above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0087] **1** cylindrical filter; **2** central axis; **3** separation target; **4** tangent; **5** water to be treated; **6**, **7** filtered water; **8** pure water; **10** casing; **11** treated water nozzle; **12** nozzle port; **12**A centerline; **13** drain flow channel; **14** drain outlet; **15**A, **15**B filtered water flow channel; **16** motor; **17** motor cover; **18** coupling portion; **18**A protrusion; **19** bearing portion; **21** filter main body; **21**A screen filter; **21**B filter support; **21**C, **35**, **36**, **45** hole; **22**A, **22**B lid body; **23**A, **23**B sealing tape; **24**A, **24**B sealing member; **25** bearing ring; **26** strut; **27** screw; **28**A, **28**B ring; **31**, **41** top surface; **32**, **42** lower surface; **33**, **43** screw hole; **34** recess; **37** groove; **46** through hole; **101**, **102** filtering apparatus; **103** reverse osmosis membrane permeation apparatus; **104** tank; **112**, **113** filter; **201** saline water conversion system; A point; D distance; R radius of curvature.

1. A filtering apparatus comprising:
- a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric;
- a treated water nozzle including a nozzle port through which water to be treated flows out to a surface of the screen filter;
- a casing where the cylindrical filter is accommodated, the casing containing the nozzle port in inside;
- a filtered water flow channel through which filtered water obtained by passage of water to be treated through the screen filter is guided to outside of the casing, the filtered water flow channel being provided with a flow inlet provided in the inside of the casing; and
- a rotation mechanism that rotates the cylindrical filter with a central axis of the cylindrical filter being defined as a center, wherein
  - a distance between a centerline of the nozzle port along a direction of outflow of water to be treated and the central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

2. The filtering apparatus according to claim **1**, wherein an angle formed by the centerline of the nozzle port with respect to a tangent of the cylindrical filter at an intersection between the centerline of the nozzle port and a surface of the cylindrical filter is equal to or larger than 1° and equal to or smaller than 45°.

3. The filtering apparatus according to claim **2**, wherein the angle is equal to or larger than 5° and equal to or smaller than 15°.

4. The filtering apparatus according to claim **1**, wherein the cylindrical filter includes
- a cylindrical filter support including a surface in contact with an inner circumferential surface of the screen filter, the filter support having a plurality of holes provided in the surface,
- a strut arranged in inside of the filter support, the strut extending along a direction of the central axis of the cylindrical filter,
- a first fixing member arranged at a first end of the filter support to fix the strut at the first end,
- a second fixing member arranged at a second end of the filter support opposite to the first end to fix the strut at the second end,
- a first sealing member that seals a gap between the first fixing member and the screen filter on a side of the first end of the filter support, and
- a second sealing member that seals a gap between the second fixing member and the screen filter on a side of the second end of the filter support,

the rotation mechanism includes a coupling portion including a protruding portion,

the first fixing member is provided with a recess constructed to receive the protruding portion of the coupling portion, and

the second fixing member is provided with a through hole for passage of the filtered water flow channel.

5. A water treatment system comprising the filtering apparatus comprising:

a filtering apparatus, the filtering apparatus comprising:

a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric;

a treated water nozzle including a nozzle port through which water to be treated flows out to a surface of the screen filter;

a casing where the cylindrical filter is accommodated, the casing containing the nozzle port in inside;

a filtered water flow channel through which filtered water obtained by passage of water to be treated through the screen filter is guided to outside of the casing, the filtered water flow channel being provided with a flow inlet provided in the inside of the casing; and

a rotation mechanism that rotates the cylindrical filter with a central axis of the cylindrical filter being defined as a center, wherein

a distance between a centerline of the nozzle port along a direction of outflow of water to be treated and the central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

6. A filtering method of filtering water to be treated by a cylindrical filter including a cylindrical screen filter made of a woven fabric or a nonwoven fabric, the filtering method comprising:

rotating the cylindrical filter; and

causing water to be treated to flow out of a nozzle port of a treated water nozzle such that water to be treated passes through the screen filter, wherein

the causing water to be treated to flow out includes causing water to be treated to flow out in such a direction that a distance between a centerline of the nozzle port along a direction of outflow of water to be treated and a central axis of the cylindrical filter is shorter than a radius of the cylindrical filter.

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